

Ice cream scheduling

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EWO meeting, 28 September 2010



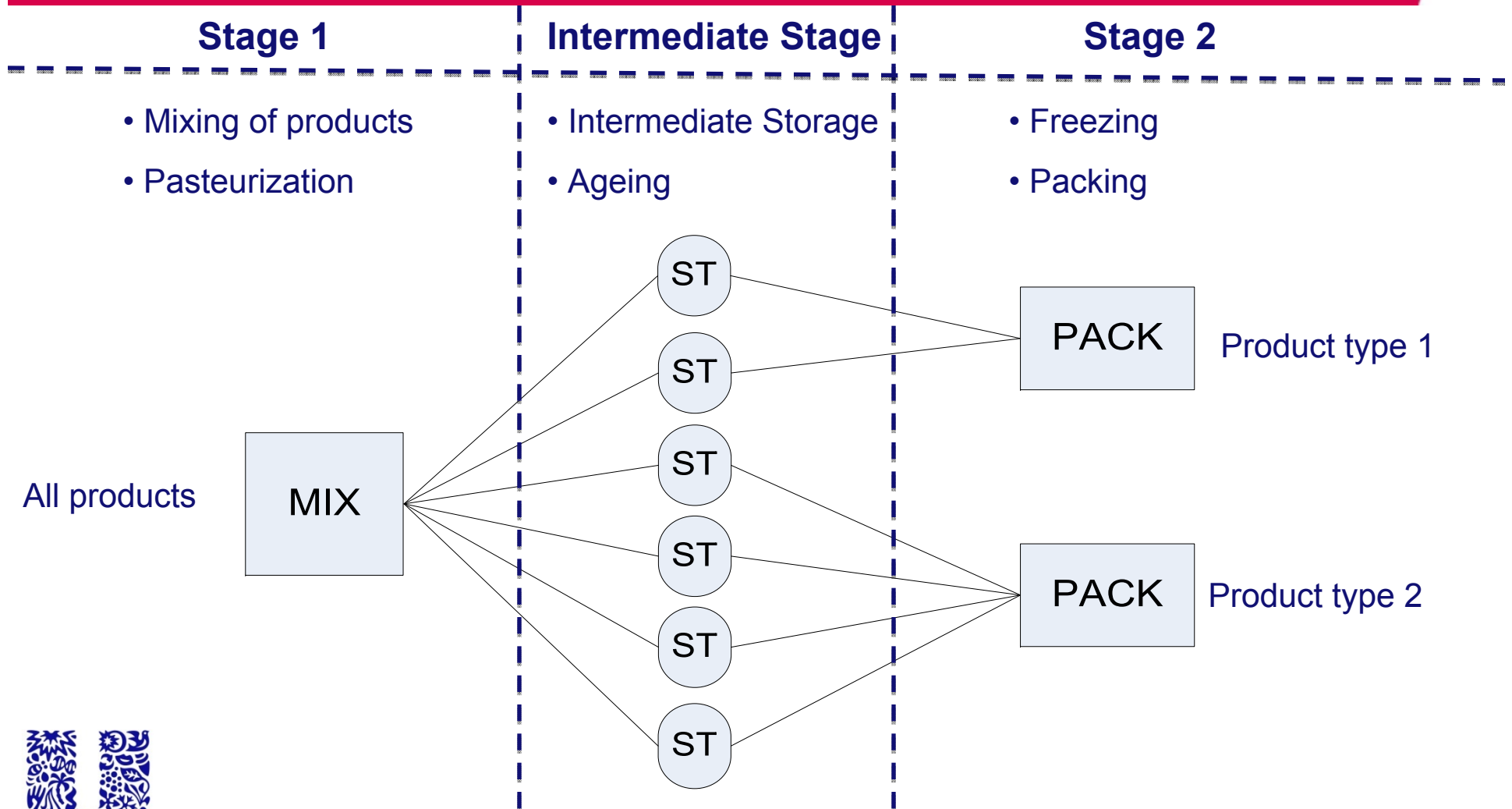
Process Systems Engineering



Technische Universiteit
Eindhoven
University of Technology

Where innovation starts

Problem overview



Process Specifics

- ❑ **Production runs**
 - **Single continuous packing campaigns**
 - **Mixer changes between products**
 - **Only mixing full storage tanks**
 - **Batch identity must be retained**

- ❑ **Sequence dependent changeovers**

- ❑ **Additional periodical cleaning periods**

Main Challenge

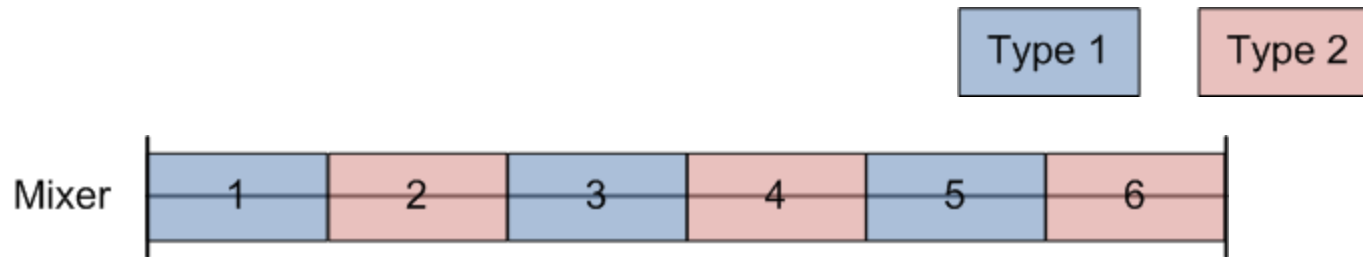
❑ Intermediate inventory

1. Limited storage capacity leads to many mixer switches
 - Must ensure continuous packing runs

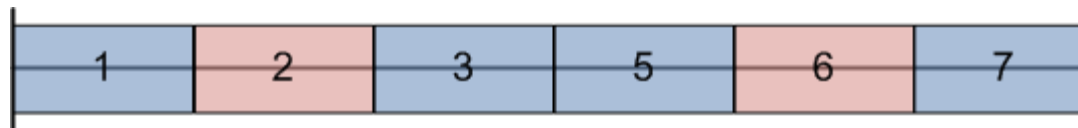
2. Considerably more storage tanks than mixers and packers
 - Model size largely determined by storage stage

Dedicated time slots

1. Limited storage capacity leads to many mixer switches
 - Observation: Almost never two consecutive mixing runs of the same product class (same packer)
 - Dedicate product types to periods → Smaller model



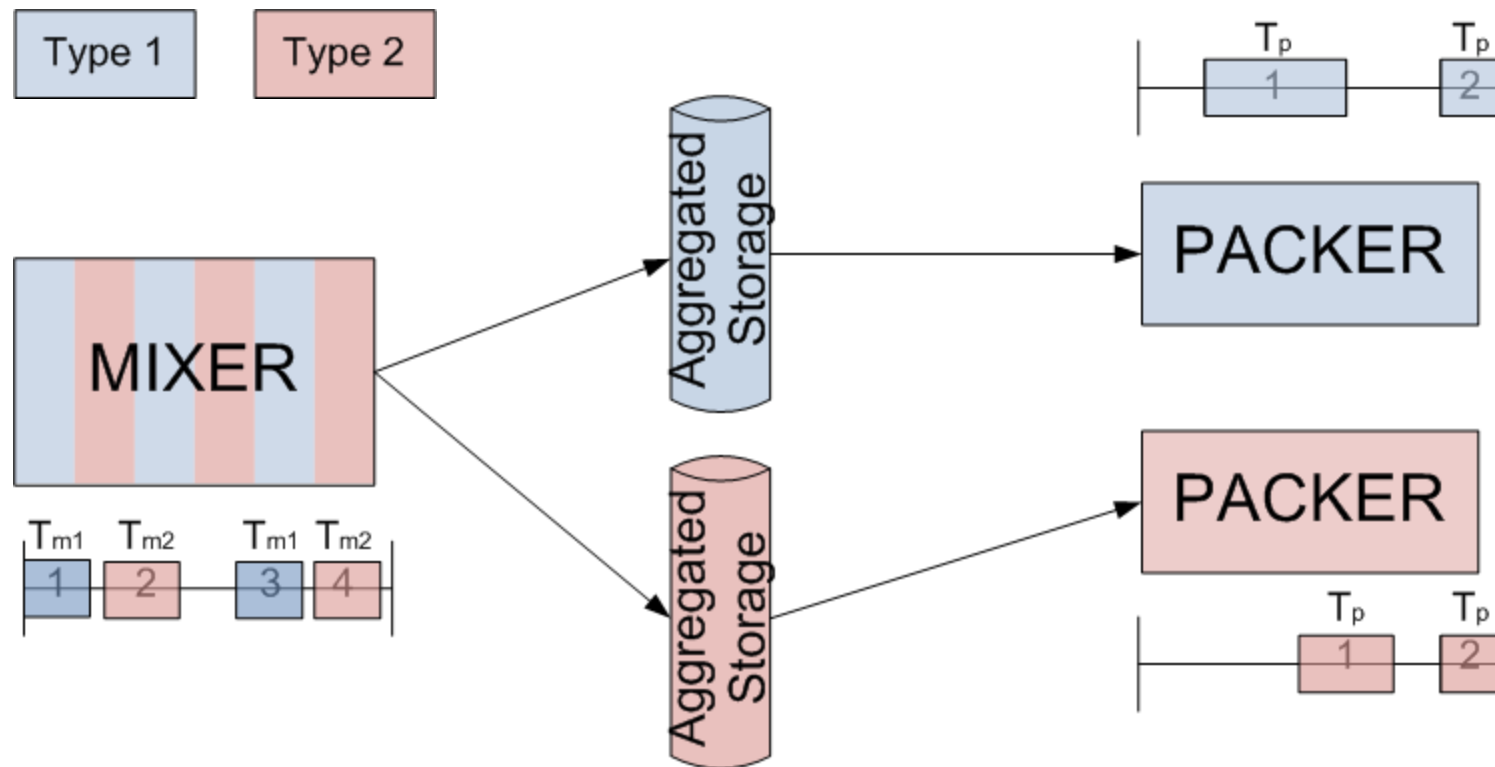
- Empty periods ensure flexibility



Intermediate storage

2. Considerably more storage tanks than mixers and packers
 - Model size determined by intermediate storage stage
 - Alternative inventory modeling
 - Aggregated storage
 - Relate mixing and packing periods

Aggregated Storage Model

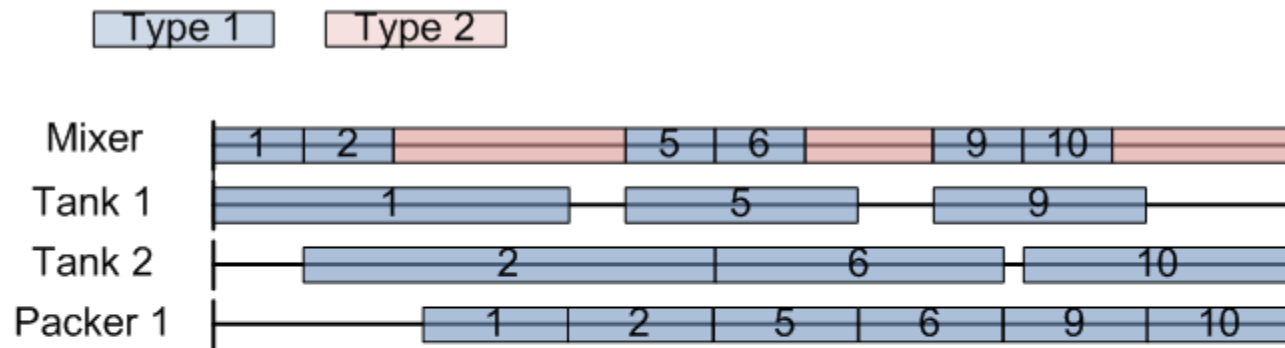


Aggregated Storage Model

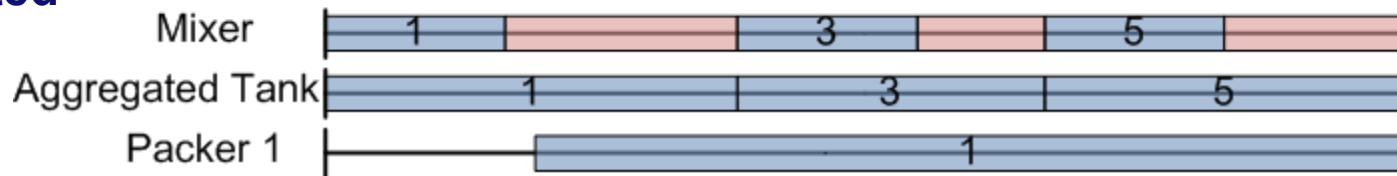
□ Advantage

- **Smaller model**
 - Only one inventory per product type to consider
 - Less breaking up of periods

Normal



Aggregated

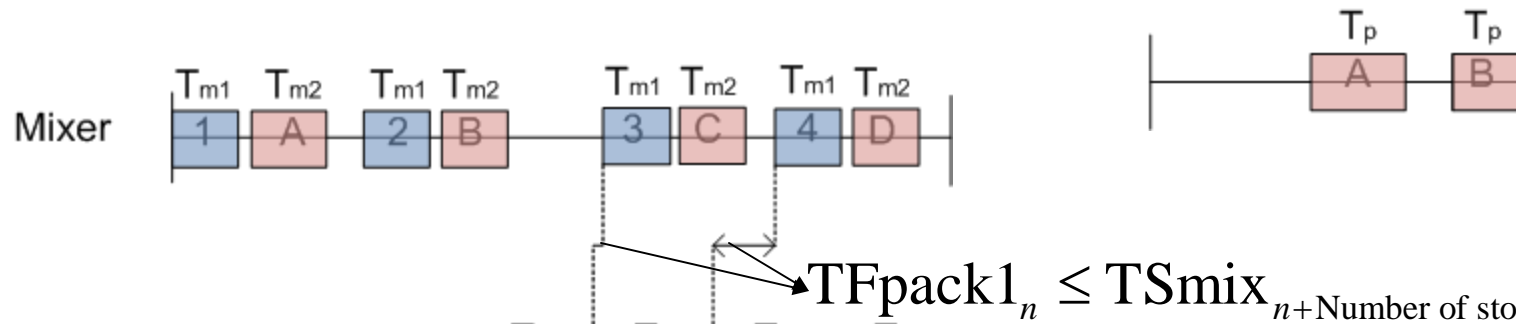
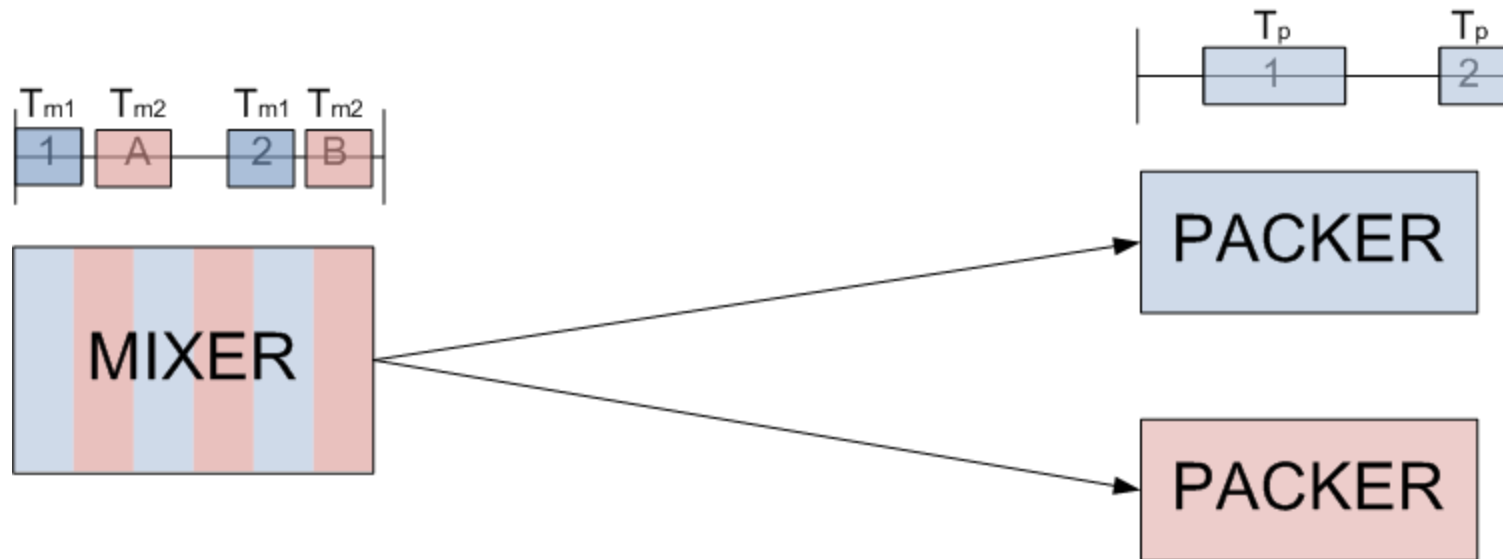


Aggregated inventory storage

□ Challenges

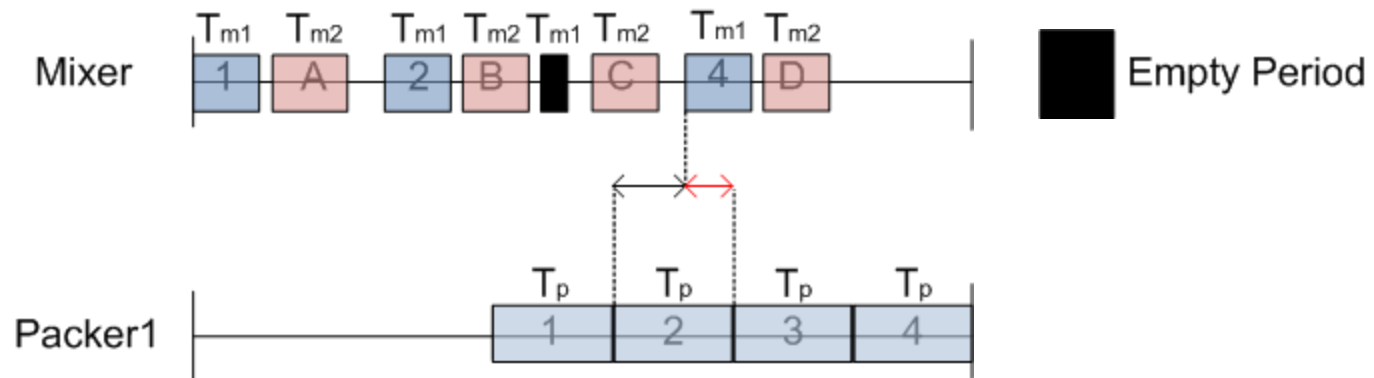
- No mixing of different products
 - Batch identity
- Checking inventory at end period is not enough
- Sufficient storage must be available at start
 - Only production of full tanks
 - Mixing products never required if storage available

Related Period Model



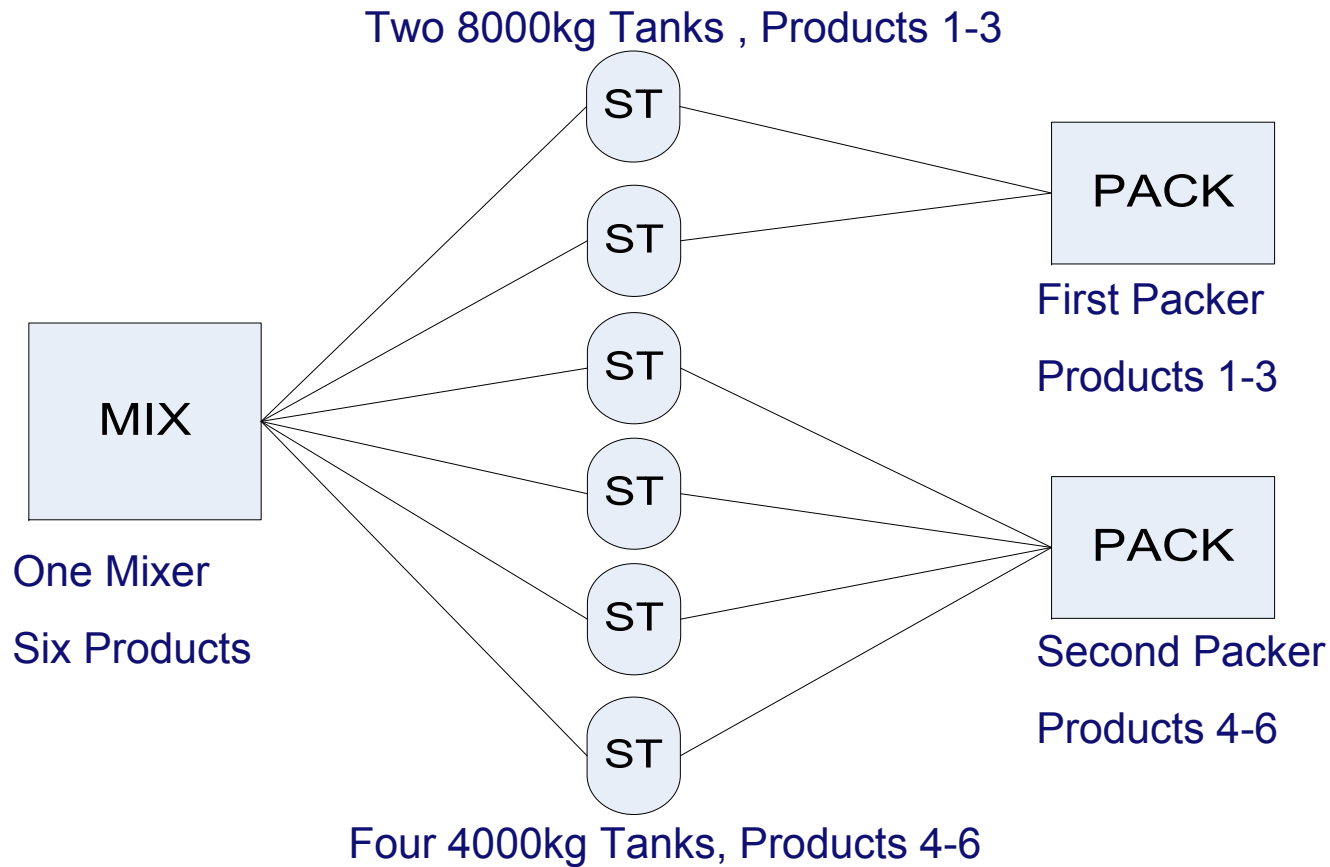
Related Periods Model

- ❑ No intermediate stage to model, simpler model
- ❑ Empty periods not counted when relating periods



Small Example Problem

- 48 hr horizon
- 2hr cleaning period



Computational Results

□ Feasibility

	Time slots	Variables (Integer)	Constraints	Required Comp. Time*	Number of Nodes
Aggregated Storage Model	19	1559(302)	2214	>1 hr	>30k
Aggregated Storage Model - Dedicated Time Periods	19	1559(302)	2216	320s	2701
Related Periods Model	36	1946(108)	2088	6.97s	62

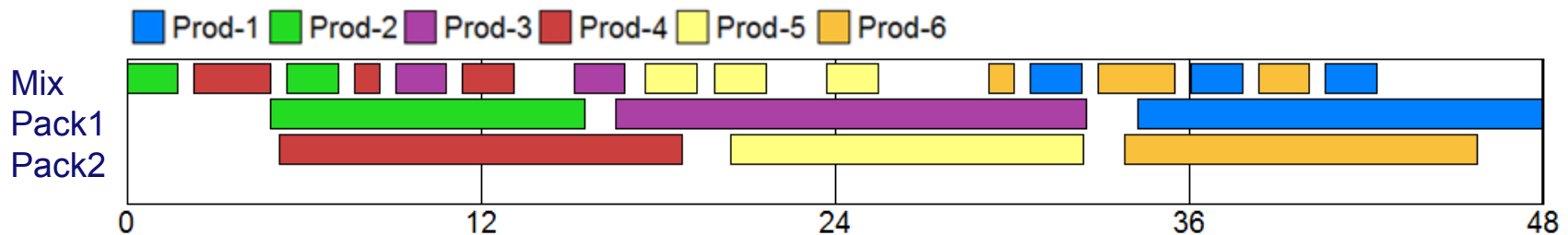
□ Makespan minimization

	Time slots	Variables (Integer)	Constraints	Required Comp. Time*	Number of Nodes	Makespan
ASM - DTP	19	1559(302)	2216	411 min	916034	45.61hr
RPM	36	1946(108)	2088	20 min	59096	45.61hr

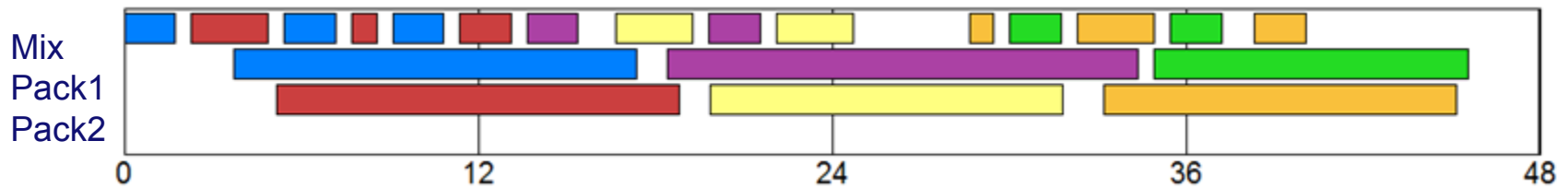
* Gurobi 3.0 was used as solver

Results: Schedules

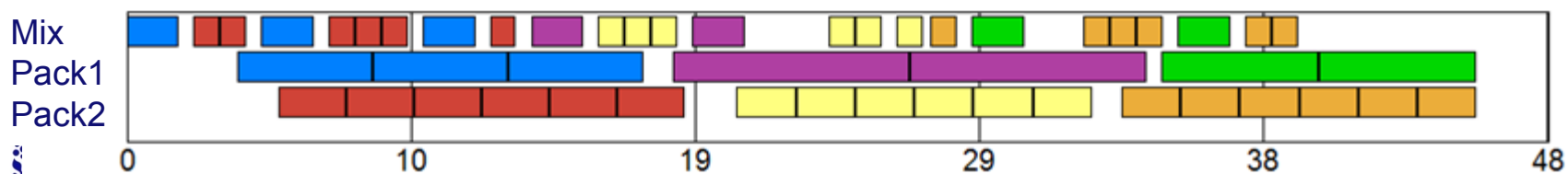
Feasibility, Aggregated Storage Model



Makespan minimization, Aggregated Storage Model



Makespan minimization, Related Period Model



Future Work

- ❑ Compare with RTN formulation

- ❑ Larger case
 - 120 hr horizon, 8 products
 - Application of heuristics

- ❑ Planning model